

# **April 1997**

## **Preliminary Data Summary**

by      Field Research Facility

U.S. Army Corps of Engineers  
Waterways Experiment Station  
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# Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

**Data from these reports are now available via the World Wide Web at**  
**<http://www.frf.usace.army.mil>**

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Your comments and suggestions are welcome.

# Introduction

## 1

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The U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 ([c.baron@cerc.wes.army.mil](mailto:c.baron@cerc.wes.army.mil)).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 2.

Times given in the report are referenced to eastern standard time (EST).

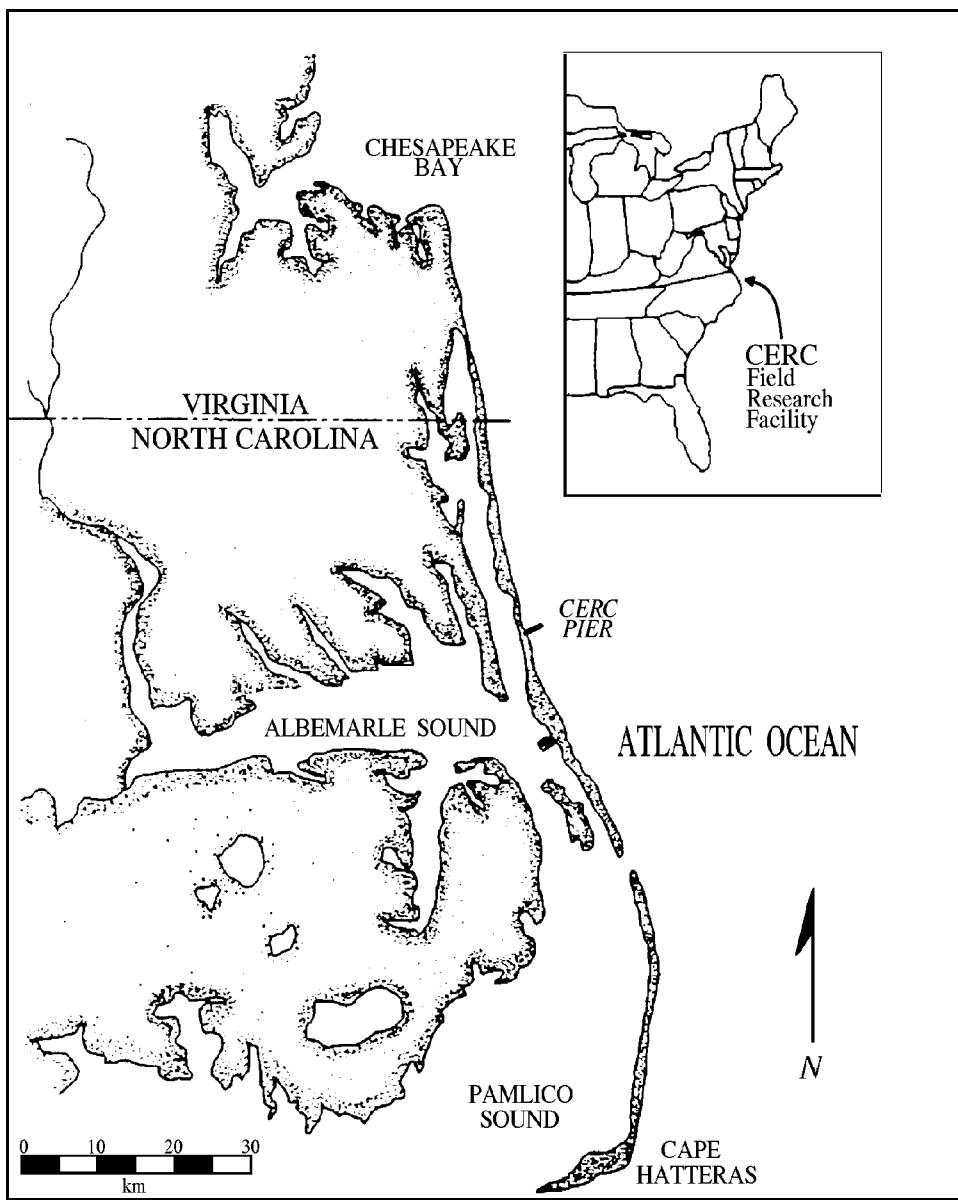


Figure 1. FRF Location Map

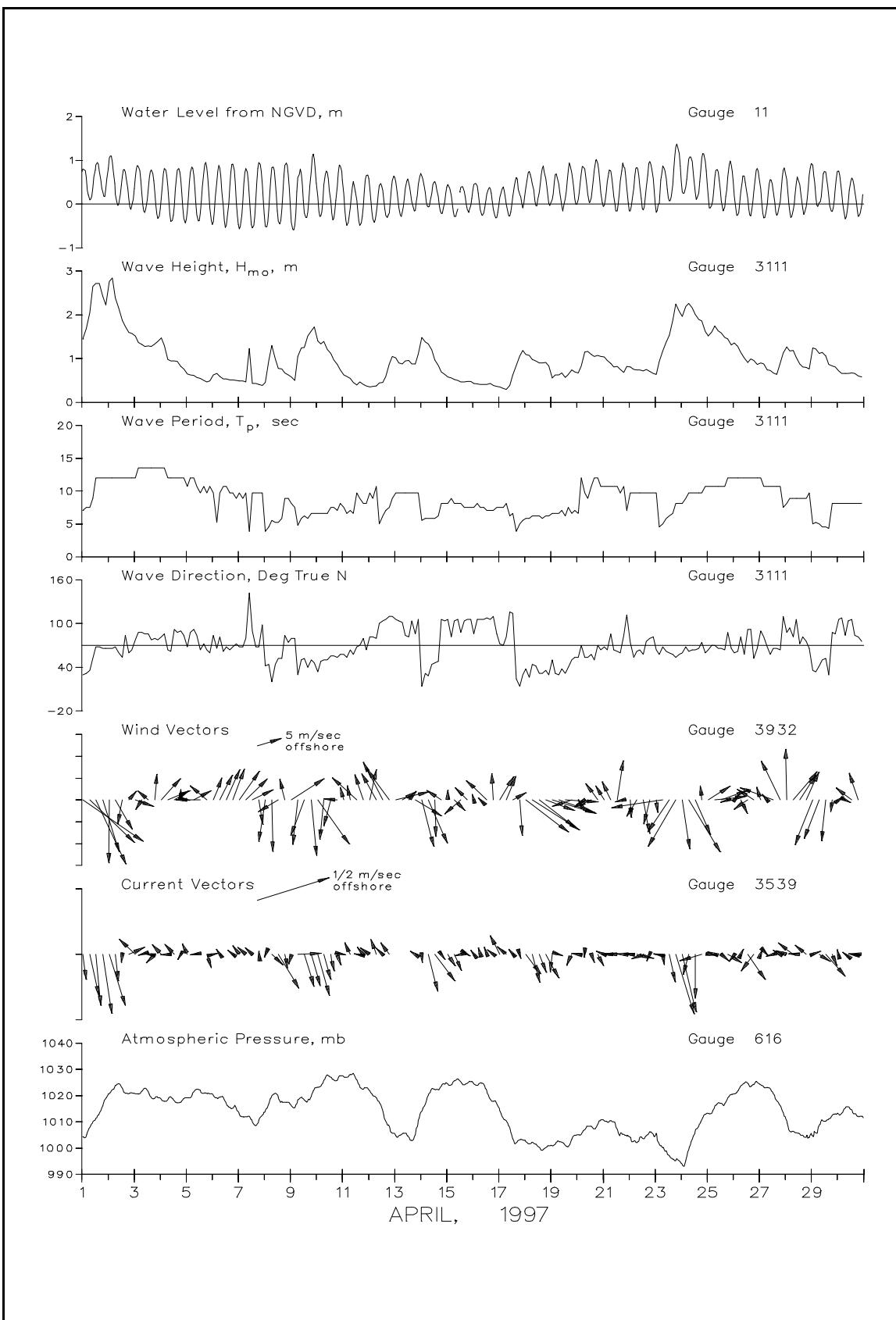


Figure 2. Month at a Glance

**Table 1**  
**Instrument Status/Data Availability**

		April 1997																																	
		Day of the month																																	
Gauge ID	Description/Remarks	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0				
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Visual Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Gauge Status		*	= Operational	/	= Partial	-	= Non-Operational																												
Data Collected		*	= All	/	= Partial	-	= None																												
Visual Observations		*	= Complete	/	= Partial	-	= None																												

**Table 2**  
**Gauge Locations**

Gauge*	Description	* Latitude	* Longitude	* FRF Coordinates	* Gauge Depth	* Water Depth	
ID *		* Degrees N	* Degrees W	* Crossshore	T Longshore*	NGVD, m	* NGVD, m
616	* Atmospheric Pressure	* 36 10' 57.03"	* 75 45' 5.50"	* 11.60	* 569.00	* -----	* -----
3932	* Anemometer	* 36 11' 1.23"	* 75 44' 43.07"	* 585.20	* 517.30	* 19.50	* -----
641	* Pressure Gauge	* 36 10' 57.71"	* 75 44' 56.23"	* 239.11	* 516.64	* -1.64	* -1.96
625	* Baylor Staff	* 36 11' 1.04"	* 75 44' 43.72"	* 568.00	* 516.64	* Surface	* -8.36
3111	* 8 Meter Array North	* 36 11' 19.14"	* 75 44' 36.41"	* 915.23	* 990.16	* -7.50	* -7.90
	* 8 Meter Array South	* 36 11' 11.28"	* 75 44' 33.28"	* 914.20	* 735.37	* -7.42	* -7.90
	* 8 Meter Array East	* 36 11' 13.70"	* 75 44' 32.56"	* 954.51	* 800.58	* -7.62	* -8.13
	* 8 Meter Array West	* 36 11' 12.48"	* 75 44' 37.11"	* 834.66	* 800.37	* -6.98	* -7.44
111	* Pressure Gauge in * center of 8 M Array	* 36 11' 14.06"	* 75 44' 34.39"	* 914.43	* 825.52	* -7.76	* -8.08
630	* Waverider Buoy	* 36 10' 5.10"	* 75 41' 59.30"	* 3934.96	* -2400.81	* Surface	* -17.00
3539	* Current Meter	* 36 11' 23.57"	* 75 44' 9.12"	* 1605.80	* 907.60	* -11.60	* -11.70
11	* NOAA Tide Gauge	* 36 11' 1.25"	* 75 44' 42.60"	* 596.49	* 514.20	* Surface	* -7.62

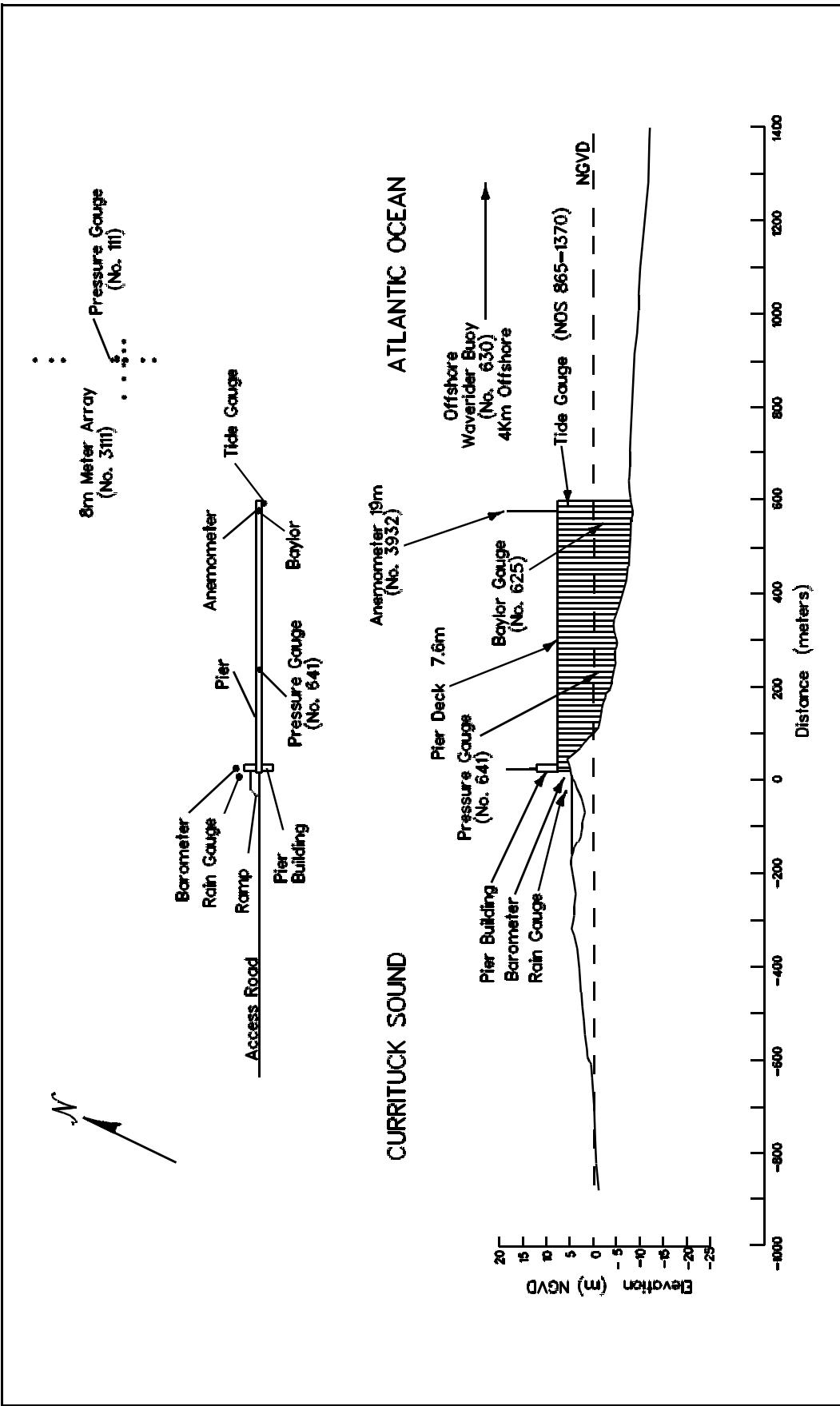


Figure 3. Instrument Locations, Elevations From NGVD

# Meteorological Data

## 2

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A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

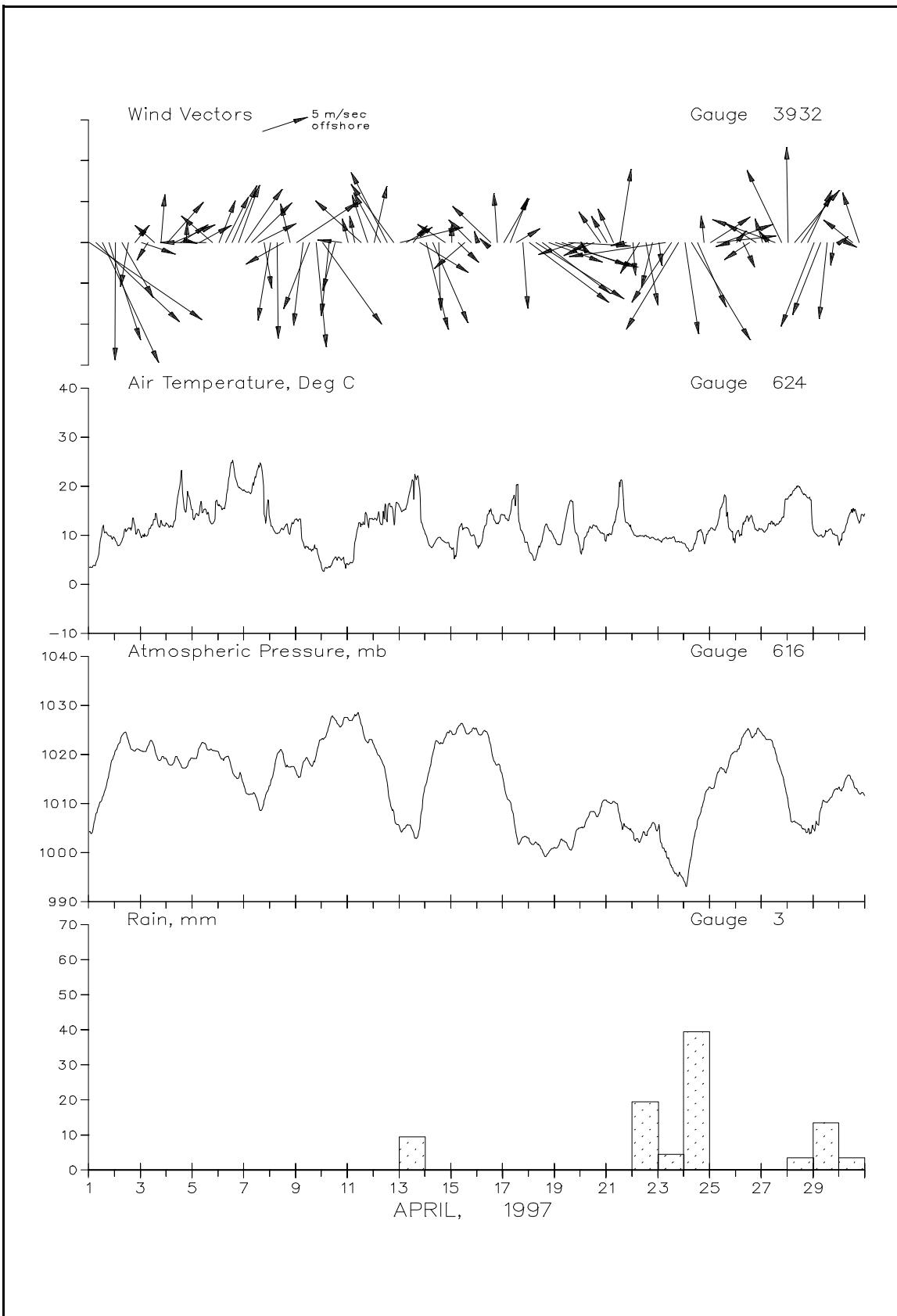


Figure 4. Meteorological Monthly Summary

**Table 3**  
**Meteorological Data**

Apr 1997						
Precipitation	Wind		Wind	Temperature	Atm	
	Day	Hour	Speed m/sec	Direction deg TN	deg C	Pressure mb
						mm
1	100	15	308	3.4	1004.3	0
	700	13	317	4.4	1008.1	0
	1300	16	338	11.5	1011.4	0
	1900	12	344	9.9	1016.2	0
2	100	14	1	8.9	1020.9	0
	700	7	334	8.9	1023.9	0
	1300	5	8	11.5	1022.9	0
	1900	3	215	12.0	1020.8	0
3	100	4	291	9.4	1020.8	0
	700	2	28	10.2	1021.8	0
	1300	3	135	13.3	1021.5	0
	1900	6	184	13.0	1019.0	0
4	100	6	217	12.3	1018.6	0
	700	5	243	12.7	1018.4	0
	1300	4	233	21.1	1018.1	0
	1900	2	180	15.6	1017.5	0
5	100	0		13.4	1019.3	0
	700	4	238	14.9	1021.5	0
	1300	5	89	15.2	1022.0	0
	1900	5	134	12.3	1020.9	0
6	100	5	198	16.3	1020.2	0
	700	6	203	16.5	1019.5	0
	1300	7	200	24.8	1017.0	0
	1900	7	197	19.8	1015.3	0
7	100	8	211	18.9	1013.0	0
	700	6	221	18.9	1012.1	0
	1300	5	240	23.6	1010.2	0
	1900	6	352	14.3	1010.7	0
8	100	10	8	12.5	1014.3	0
	700	12	359	10.3	1020.0	0
	1300	5	56	11.2	1019.4	0
	1900	5	167	10.4	1017.5	0
9	100	8	232	13.3	1016.2	0
	700	10	5	8.6	1018.4	0
	1300	9	18	7.1	1018.3	0
	1900	13	355	7.3	1019.9	0
10	100	12	328	2.8	1023.3	0
	700	9	5	3.7	1026.0	0
	1300	6	12	5.6	1027.1	0
	1900	3	96	5.1	1026.0	0

**Table 3**  
**Meteorological Data (continued)**

Apr 1997							
Precipitation	Wind		Temperature		Atm		
	Day	Hour	Speed m/sec	Direction deg TN	deg C	Pressure mb	
	11	100	3	167	4.0	1027.3	0
		700	3	170	8.5	1028.2	0
		1300	7	136	12.3	1026.2	0
		1900	6	164	12.5	1022.4	0
	12	100	7	191	13.2	1021.9	0
		700	7	154	12.2	1019.2	0
		1300	9	156	12.7	1014.4	0
		1900	8	147	13.2	1008.5	0
	13	100	7	254	15.6	1004.8	0
		700	3	235	15.8	1005.6	9
		1300	2	215	21.0	1004.2	0
		1900	6	305	19.3	1005.1	0
	14	100	11	347	10.0	1014.1	0
		700	11	339	7.7	1020.2	0
		1300	8	358	9.6	1022.4	0
		1900	4	126	8.6	1023.5	0
	15	100	2	179	7.1	1024.5	0
		700	3	318	9.8	1025.7	0
		1300	5	45	11.5	1025.3	0
		1900	4	1	9.8	1024.8	0
	16	100	1	165	7.7	1024.6	0
		700	1	1	11.5	1025.0	0
		1300	6	137	15.4	1021.8	0
		1900	6	176	12.6	1017.9	0
	17	100	6	206	14.1	1014.3	0
		700	6	198	14.5	1010.4	0
		1300	3	236	20.3	1003.7	0
		1900	8	356	10.3	1003.3	0
	18	100	11	311	6.7	1002.5	0
		700	12	306	5.4	1002.2	0
		1300	10	311	9.3	1000.4	0
		1900	6	293	11.3	1000.2	0
	19	100	9	1	9.1	1001.0	0
		700	8	1	8.9	1002.7	0
		1300	7	1	15.9	1001.2	0
		1900	4	68	11.0	1003.4	0
	20	100	0		6.1	1005.2	0
		700	2	55	10.6	1007.1	0
		1300	4	63	12.0	1008.4	0
		1900	4	148	10.5	1009.1	0

**Table 3**  
**Meteorological Data (concluded)**

Apr 1997							
Precipitation	Wind		Wind		Temperature	Atm	
	Day	Hour	Speed m/sec	Direction deg TN	deg C	Pressure mb	
						mm	
	21	100	4	152	10.1	1010.5	0
		700	4	158	12.0	1010.5	0
		1300	9	187	19.8	1007.2	0
		1900	2	75	12.5	1005.4	0
	22	100	4	1	10.6	1004.1	0
		700	4	27	9.9	1002.1	20
		1300	8	1	10.0	1003.6	0
		1900	6	12	9.5	1006.2	0
	23	100	3	1	9.0	1005.8	0
		700	10	80	9.5	1000.2	4
		1300	8	30	9.3	997.1	0
		1900	12	27	8.8	995.2	0
	24	100	11	1	8.2	993.9	0
		700	13	1	6.9	999.5	39
		1300	8	339	10.8	1006.6	0
		1900	3	174	8.6	1010.8	0
	25	100	5	233	11.4	1013.3	0
		700	6	262	12.0	1016.0	0
		1300	6	246	16.8	1017.1	0
		1900	2	70	11.2	1019.3	0
	26	100	2	216	10.5	1020.7	0
		700	3	337	12.5	1023.7	0
		1300	3	51	13.6	1024.8	0
		1900	4	126	11.2	1024.2	0
	27	100	3	165	11.1	1024.1	0
		700	2	144	12.4	1023.2	0
		1300	7	112	11.9	1020.8	0
		1900	10	157	13.4	1016.3	0
	28	100	12	179	17.5	1010.4	0
		700	8	216	19.4	1006.5	4
		1300	7	209	19.3	1005.6	0
		1900	7	201	17.7	1004.3	0
	29	100	11	18	10.8	1004.7	0
		700	9	18	10.0	1008.8	13
		1300	9	4	10.8	1010.3	0
		1900	3	5	10.2	1012.5	0
	30	100	1	229	8.4	1013.0	0
		700	1	297	12.2	1015.3	4
		1300	4	131	14.7	1014.7	0
		1900	6	163	12.5	1012.2	0
Total				Resultant	Mean	Mean	
				—	—	—	
			1	315	11.8	1014.0	

# Wave Data

## 3

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Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

Apr 1997										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	1.37	7.2	1.42	6.8	1.45	7.1	30	2.09	7.7
	0700	1.41	8.1	1.86	7.6	2.06	7.6	36	2.24	7.2
	1300	1.66	9.2	2.47	9.9	2.72	12.0	68	2.83	9.1
	1900	1.32	11.2	2.18	12.2	2.41	12.0	66	2.61	11.8
2	0100	1.61	12.9	2.39	12.9	2.77	12.0	66	2.74	11.8
	0700	1.22	12.2	2.34	12.2	2.38	12.0	68	2.84	12.6
	1300	1.36	12.2	1.86	12.2	1.88	12.0	54	2.14	11.8
	1900	1.09	12.2	1.55	12.2	1.60	12.0	60	1.80	11.8
3	0100	0.89	12.2	1.27	11.7	1.51	12.0	78	1.44	11.8
	0700	0.84	14.3	1.15	13.5	1.32	13.6	88	1.25	10.1
	1300	0.70	13.5	1.14	13.5	1.29	13.6	86	1.17	13.4
	1900	0.75	13.5	1.16	12.9	1.33	13.6	80	1.31	11.8
4	0100	0.83	12.2	1.42	12.2	1.47	13.6	82	1.42	11.8
	0700	0.59	12.9	1.04	12.9	0.98	12.0	64	1.18	11.2
	1300	0.42	12.9	0.86	11.7	0.94	12.0	92	0.96	11.8
	1900	0.41	11.7	0.66	11.7	0.82	12.0	90	0.90	11.8
5	0100	0.31	10.7	0.62	11.2	0.64	10.8	68	0.73	11.8
	0700	0.31	12.9	0.52	11.2	0.61	12.0	92	0.62	10.1
	1300	0.23	12.2	0.46	9.5	0.55	9.8	64	0.62	11.2
	1900	0.30	10.7	0.50	11.2	0.47	9.8	64	0.61	10.1
6	0100	0.31	9.5	0.56	10.7	0.62	9.8	84	0.62	10.1
	0700	0.34	4.8	0.59	10.3	0.60	9.8	82	0.73	10.1
	1300	0.19	4.5	0.49	9.2	0.53	10.8	68	0.61	10.6
	1900	0.27	10.7	0.49	9.5	0.51	9.8	68	0.62	10.1
7	0100	0.17	9.9	0.43	10.3	0.49	9.8	68	0.64	10.1
	0700	0.28	7.0	0.45	9.5	0.47	9.8	80	0.59	8.4
	1300	0.18	7.0	0.39	10.7	0.43	9.8	90	0.61	10.1
	1900	0.25	9.5	0.40	9.2	0.41	9.8	68	0.50	10.1
8	0100	0.27	2.9	0.52	9.9	0.45	3.9	42	0.64	10.1
	0700	1.10	5.5	1.35	5.5	1.30	5.6	20	1.78	5.3
	1300	0.60	5.2	0.78	5.2	0.78	5.3	52	1.18	5.3
	1900	0.54	5.6	0.65	5.7	0.67	8.9	84	1.00	5.6
9	0100	0.21	13.5	0.53	8.1	0.58	8.2	80	0.71	8.4
	0700	0.58	3.8	0.90	4.0	1.04	4.8	30	0.94	3.5
	1300	0.96	6.3	1.17	6.5	1.26	6.2	52	1.53	6.3
	1900	1.40	5.7	1.59	6.3	1.63	6.6	50	2.10	6.3
10	0100	1.21	6.5	1.40	6.6	1.40	6.6	34	1.90	6.7
	0700	1.16	6.6	1.39	6.8	1.39	6.6	50	1.67	6.3
	1300	0.96	7.4	1.11	7.4	1.12	7.6	56	1.37	7.2
	1900	0.72	7.0	0.92	7.2	0.87	7.1	54	1.09	7.2

**Table 4**  
**Wave Data (continued)**

Apr 1997											
Day	Hour	641		625		3111			630		
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	Gauge Tp,sec	8 Hmo,m	Meter Tp,sec	Array Dir,TN	Waverider Hmo,m	Tp,sec	
11	0100	0.43	7.8	0.62	7.4	0.62	7.6	58	0.78	7.7	
	0700	0.29	6.3	0.48	6.1	0.55	7.1	64	0.60	7.2	
	1300	0.24	5.4	0.47	8.9	0.40	9.8	68	0.62	2.8	
	1900	0.21	3.3	0.45	8.9	0.41	8.2	80	0.69	3.4	
12	0100	0.17	10.3	0.35	7.6	0.35	9.8	82	0.47	11.2	
	0700	0.17	9.5	0.34	7.8	0.38	10.8	80	0.45	11.2	
	1300	0.27	5.4	0.44	10.7	0.45	6.2	104	0.64	5.3	
	1900	0.50	7.6	0.82	7.4	0.87	7.6	110	1.23	7.7	
13	0100	0.68	9.5	0.91	9.2	1.01	9.8	106	1.20	9.1	
	0700	0.52	10.3	0.86	9.5	0.88	9.8	102	1.05	8.4	
	1300	0.59	9.9	0.92	10.3	0.95	9.8	82	1.07	10.1	
	1900	0.47	9.9	0.84	9.9	0.88	9.8	86	1.03	10.1	
14	0100	1.21	5.6	1.46	5.6	1.48	5.6	14	1.48	10.0	
	0700	1.16	6.0	1.24	6.0	1.33	5.9	28			
	1300	0.92	5.9	1.02	5.7	0.97	5.9	46	inoperative		
	1900	0.51	5.9	0.66	8.3	0.70	8.2	106			
15	0100	0.41	5.4	0.55	8.9	0.58	8.2	106			
	0700	0.26	5.7	0.49	8.3	0.52	8.2	104	0.59	9.1	
	1300	0.28	7.8	0.43	8.1	0.47	8.2	88	0.55	7.7	
	1900	0.25	7.8	0.48	7.4	0.47	7.6	106	0.56	7.7	
16	0100	0.25	7.8	0.43	7.8	0.43	7.6	86	0.54	7.7	
	0700	0.20	7.6	0.38	7.8	0.40	7.6	106	0.47	7.7	
	1300	0.23	7.4	0.43	6.8	0.40	7.1	108	0.55	7.2	
	1900	0.22	6.8	0.41	7.4	0.38	7.1	110	0.71	3.5	
17	0100	0.17	7.2	0.33	7.2	0.35	7.6	72	0.48	7.2	
	0700	0.13	7.4	0.28	7.0	0.30	8.2	82	0.34	7.2	
	1300	0.37	6.1	0.53	6.5	0.62	6.6	114	0.72	6.3	
	1900	0.68	4.7	0.93	4.9	1.06	5.0	14	1.30	4.8	
18	0100	1.06	5.9	1.09	5.9	1.10	5.9	38	1.44	5.9	
	0700	0.98	6.3	0.99	6.5	0.98	6.2	44	1.41	5.9	
	1300	0.90	6.0	0.94	6.1	0.90	6.2	32	1.29	5.9	
	1900	0.88	6.1	0.90	6.5	0.91	6.2	36	1.27	5.9	
19	0100	0.61	6.8	0.58	7.0	0.56	6.6	50	1.14	6.7	
	0700	0.64	6.8	0.61	6.6	0.62	6.6	30	0.96	6.7	
	1300	0.55	6.3	0.57	6.6	0.57	6.2	32	0.83	7.2	
	1900	0.71	7.0	0.73	6.8	0.74	6.6	50	0.87	8.4	
20	0100	0.54	6.5	0.65	6.3	0.67	6.6	54	0.86	6.7	
	0700	0.94	10.7	1.19	10.7	1.15	9.8	54	1.27	10.6	
	1300	0.78	9.2	1.03	9.2	1.10	10.8	58	1.34	9.1	

**Table 4**  
**Wave Data (concluded)**

Apr 1997											
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
21	0100	0.56	11.2	0.93	10.7	1.03	10.8	68	1.02	10.1	
	0700	0.49	10.7	0.83	10.3	0.88	10.8	86	0.88	11.2	
	1300	0.37	10.7	0.78	10.3	0.81	10.8	62	0.97	10.1	
	1900	0.37	10.7	0.61	9.2	0.69	10.8	84	0.75	10.1	
22	0100	0.43	7.2	0.72	9.9	0.81	9.8	74	1.04	6.3	
	0700	0.49	9.5	0.76	9.9	0.74	9.8	62	1.02	6.3	
	1300	0.54	5.1	0.76	9.9	0.72	9.8	58	1.00	10.1	
	1900	0.56	9.5	0.78	8.3	0.71	9.8	80	0.92	9.1	
23	0100	0.39	5.5	0.65	6.0	0.64	9.8	64	0.81	5.6	
	0700	0.76	5.3	1.25	4.9	1.18	5.0	68	1.51	4.8	
	1300	0.93	5.9	1.49	5.9	1.52	6.2	60	1.76	5.6	
	1900	1.80	7.8	2.35	7.6	2.24	8.2	54	2.64	7.7	
24	0100	1.21	8.3	1.95	8.6	1.96	8.2	60	2.50	8.4	
	0700	1.59	9.5	2.12	9.9	2.26	9.8	62	2.48	8.4	
	1300	1.23	9.2	1.87	10.7	2.01	9.8	64	2.15	8.4	
	1900	1.37	9.9	1.78	10.3	1.86	9.8	74	2.29	10.1	
25	0100	0.99	10.3	1.34	10.7	1.51	10.8	64	1.79	11.2	
	0700	1.29	11.2	1.69	11.2	1.75	10.8	70	1.87	10.6	
	1300	0.97	11.7	1.40	11.7	1.58	10.8	66	1.56	11.8	
	1900	1.00	11.7	1.35	11.7	1.45	12.0	88	1.78	10.6	
26	0100	0.88	12.2	1.22	12.2	1.35	12.0	60	1.47	12.6	
	0700	0.70	12.2	1.14	12.2	1.14	12.0	82	1.32	11.8	
	1300	0.50	12.2	0.91	12.2	0.91	12.0	92	1.10	11.8	
	1900	0.56	11.2	0.88	12.2	0.95	12.0	52	0.90	11.8	
27	0100	0.44	11.7	0.82	11.7	0.90	12.0	90	1.01	11.2	
	0700	0.36	10.7	0.75	10.7	0.73	10.8	68	0.86	11.8	
	1300	0.41	10.7	0.74	10.7	0.67	10.8	66	0.79	10.1	
	1900	0.43	10.3	0.82	10.3	0.90	10.8	64	0.85	11.2	
28	0100	0.75	7.8	1.10	7.8	1.27	8.2	88	1.48	7.7	
	0700	0.60	9.2	1.05	9.9	1.19	8.9	82	1.41	10.1	
	1300	0.49	8.9	0.79	10.3	0.88	8.9	72	1.16	9.1	
	1900	0.41	9.5	0.71	9.2	0.80	8.9	76	0.98	10.1	
29	0100	0.72	4.3	1.14	4.2	1.25	5.0	36	1.10	9.1	
	0700	0.76	4.9	1.18	5.1	1.12	5.0	42	1.35	5.1	
	1300	0.67	4.7	1.05	4.7	1.06	4.6	52	1.32	4.8	
	1900	0.39	4.5	0.79	8.6	0.83	8.2	88	0.97	8.4	
30	0100	0.41	8.6	0.70	8.3	0.72	8.2	106	0.90	9.1	
	0700	0.28	4.6	0.60	8.6	0.65	8.2	84	0.72	8.4	
	1300	0.34	8.3	0.64	8.3	0.67	8.2	106	0.73	8.4	
	1900	0.27	8.1	0.65	8.3	0.60	8.2	82	0.80	8.4	
Mean		0.65	8.5	0.95	8.9	0.99	9.0	69	1.17	8.8	
Std dev		0.39	2.7	0.49	2.3	0.53	2.3	22	0.58	2.4	

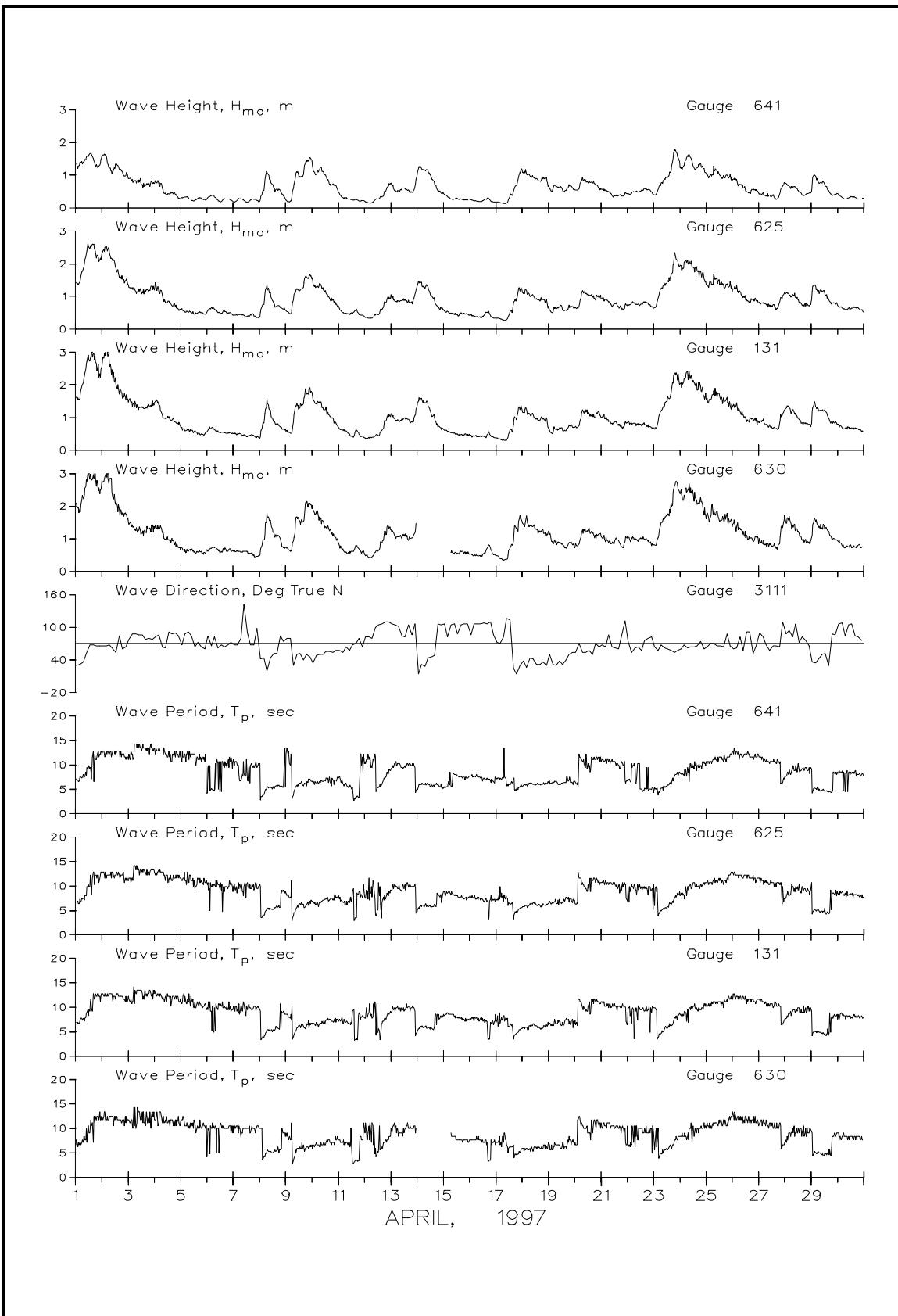


Figure 5. Wave Heights and Periods

# Current Data

## 4

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Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

APRIL 1997																	
	Cross Long				Cross Long				Cross Long								
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	5	19	19	174	11	100	0	1	2	102	21	100	4	-3	6	295
	700	5	32	32	169		700	0	-9	10	338		700	5	-1	6	270
1300	11	38	39	176		1300	2	0	2	282		1300	7	-2	7	273	
1900	10	44	45	172		1900	2	-5	6	324		1900	4	-1	4	273	
2	100	3	40	40	165	12	100	4	-6	8	309	22	100	4	-1	4	279
	700	5	20	20	175		700	0	-11	12	343		700	-8	7	11	106
1300	3	5	6	187		1300	2	-5	6	317		1300	8	1	8	245	
1900	-11	0	12	63		1900	2	-9	10	326		1900	3	4	5	202	
3	100	6	-13	15	318	13	100					23	100	1	0	2	280
	700	2	0	2	250		700						700	2	8	8	173
1300	2	0	2	279		1300							1300	4	21	21	170
1900	7	4	8	221		1900	2	-2	4	308		1900	4	47	47	165	
4	100	3	-8	9	321	14	100	2	6	6	176	24	100	6	44	45	168
	700	4	0	5	267		700	4	28	29	167		700	9	13	16	194
1300	3	-8	10	322		1300	-4	23	24	147		1300	12	31	34	180	
1900	3	3	4	206		1900	0	4	4	148		1900	15	0	15	252	
5	100	0	-8	9	337	15	100	0	10	10	152	25	100	-4	3	6	99
	700	2	0	2	262		700	0	13	13	159		700	4	-2	5	291
1300	0	0	0			1300	4	0	4	255		1300	-2	6	7	135	
1900	1	11	11	164		1900	0	2	2	127		1900	-5	9	11	125	
6	100	-2	0	3	74	16	100	1	-3	4	328	26	100	5	4	6	212
	700	1	-3	4	327		700	0	-4	5	343		700	-2	-2	4	23
1300	inoperative					1300	0	-5	6	341		1300	-3	22	22	149	
1900	2	-3	5	312		1900	3	-4	5	312		1900	12	9	15	214	
7	100	2	-7	8	327	17	100	1	-15	16	336	27	100	-1	-2	4	18
	700	3	-6	8	314		700	4	-6	8	314		700	0	1	1	142
1300	3	-5	7	315		1300	2	-4	5	322		1300	5	0	5	252	
1900	0	-1	2	354		1900	0	3	3	163		1900	3	-3	5	305	
8	100	2	2	2	201	18	100	-3	17	18	147	28	100	5	-4	7	294
	700	-3	10	11	138		700	3	22	22	167		700	6	-11	13	311
1300	-3	29	29	153		1300	0	14	14	160		1300	7	-2	7	272	
1900	2	10	11	171		1900	-1	20	20	154		1900	4	-8	10	314	
9	100	4	6	7	194	19	100	6	12	13	186	29	100	-4	0	5	67
	700	-13	4	15	87		700	-1	2	3	110		700	-4	8	9	127
1300	2	25	25	165		1300	inoperative					1300	-6	20	21	142	
1900	3	25	25	166		1900	6	7	9	202		1900	0	9	9	159	
10	100	3	32	32	166	20	100	4	-1	4	280	30	100	0	-3	4	348
	700	3	19	20	167		700	1	2	2	184		700	1	-1	2	311
1300	2	13	13	170		1300	0	6	6	161		1300	2	0	2	281	
1900	0	8	8	162		1900	0	10	10	156		1900	5	-1	5	274	

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Apr 1997												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	0	122	122	160	13	87	88	151	North	98	S	
2	0	41	41	160	11	76	77	151	North	58	S	
3	-9	16	19	189	no observation				North	52	N	
4	10	-5	11	43	19	-14	23	34	no observation			
5	10	-13	16	19	4	-7	8	9	South	21	S	
6	8	8	11	70	5	4	7	70	South	3	N	
7	10	-7	12	35	9	10	13	70	South	5	S	
8	0	68	68	160	20	102	104	149	North	55	S	
9	-11	76	77	169	9	87	88	154	North	98	S	
10	0	55	55	160	0	122	122	160	North	76	S	
11	19	-38	43	7	9	10	14	70	South	46	S	
12	0	55	55	160	0	122	122	160	North	76	S	
13	19	-38	43	7	9	10	14	70	South	46	S	
14	4	-41	41	346	-2	-17	18	334	no observation			
15	7	-20	22	359	0	-29	29	340	South	6	N	
16	0	61	61	160	0	76	76	160	North	61	S	
17	-7	68	68	166	-10	-18	21	311	North	9	S	
18	-6	-4	7	287	-1	-25	25	337	South	18	S	
19	8	-23	24	359	0	-11	11	340	South	29	N	
20	14	36	39	138	0	122	122	160	North	96	S	
21	26	29	39	118	11	38	40	143	North	19	S	
22	-9	27	28	179	0	61	61	160	North	9	S	
23	-3	-15	16	329	4	-15	15	357	South	8	N	
24	0	76	76	160	-20	102	104	171	North	107	S	
25	0	20	20	160	-3	8	8	184	no observation			
26	-8	20	22	182	11	14	17	121	no observation			
27	20	15	25	70	-4	23	24	169	North	18	S	
28	9	14	16	127	0	0	0	South	4	N		
29	0	17	17	160	12	29	31	138	North	6	S	
30	10	-38	39	354	0	-102	102	340	South	44	N	

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

# Visual Observations

## 5

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Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Apr 1997						
Day	Time	Wave Approach Angle at Pier End deg from True N		Water Characteristics at Pier End		
		Primary	Secondary	Width of Surf Zone,m	Temp.,C	Density g/cc
1	0907	40		388	8.9	1.0230 0.3
2	0745	60		433	9.4	1.0191 0.3
3	0640	70		257	10.0	1.0182 0.6
4	0830	80	40	207	10.0	1.0228 1.5
5	0649	70		66	11.1	1.0224 1.2
6	0740	90		62	12.5	1.0206 1.5
7	1020	85	125	69	11.7	1.0240 1.2
8	0924	30		83	10.8	1.0244 0.9
9	0917	25		116	11.4	1.0221 1.5
10	0654	45	15	201	10.0	1.0221 0.9
11	0805	60		79	10.6	1.0213 1.2
12	0920	105		34	11.1	1.0226 1.2
13	1044	90		87	11.4	1.0242 2.1
14	0811	30		264	10.8	1.0250 0.9
15	0809	80		78	12.8	1.0205 1.5
16	0824	80		76	12.2	1.0196 2.7
17	0754	80		74	11.1	1.0242 1.8
18	1042	40		108	10.6	1.0250 0.9
19	0930	15	55	58	10.0	1.0230 0.9
20	1000	65		79	11.1	1.0228 1.8
21	0648	80	65	82	11.7	1.0220 2.1
22	0845	30		37	11.7	1.0228 3.7
23	0905	50		88	12.2	1.0234 4.9
24	0745	60		305	10.8	1.0205 0.3
25	0722	65		254	10.8	1.0231 0.3
26	0705	70		184	11.1	1.0234 0.3
27	0845	70		55	12.5	1.0200 2.1
28	0703	100		214	11.9	1.0241 0.3
29	0811	40		104	10.8	1.0250 1.5
30	0727	90		77	11.9	1.0197 2.1

# Water Levels

## 6

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Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

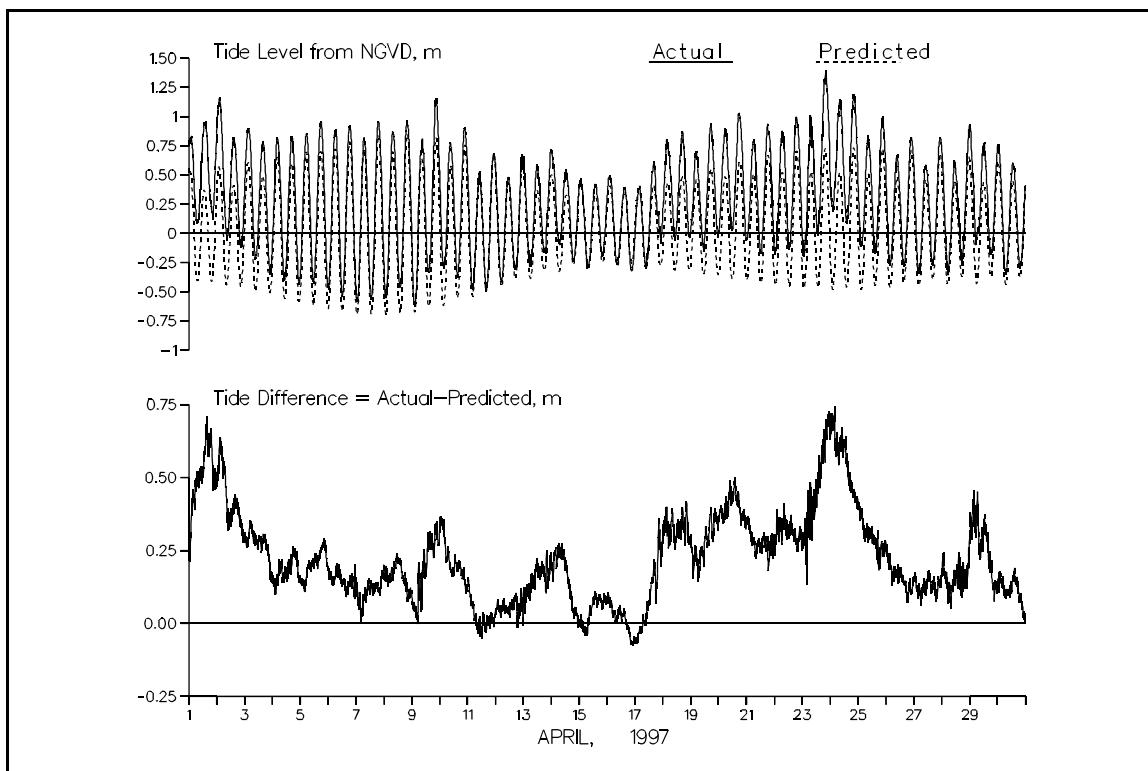


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

APR 1997 Tide Levels																
Day	High			Low			Mean	Range	High			Low			Mean	Range
	Time	m	Day	Time	m	Day			Time	m	Day	Time	m	Day		
1	0212	0.84	0	2354	0.00	0.45	0.84	16	0042	0.49	16	0730	-0.27	0.12	0.76	
1	1448	0.96	1	2048	0.12	0.57	0.84	16	1336	0.40	16	1930	-0.32	0.03	0.72	
2	0230	1.16	2	0918	-0.06	0.56	1.23	17	1242	0.44	17	0800	-0.30	0.08	0.73	
2	1430	0.82	2	2100	-0.13	0.36	0.94	18	0054	0.64	17	2024	-0.09	0.30	0.72	
3	0324	0.90	3	0918	-0.22	0.36	1.13	18	0154	0.81	18	0842	-0.06	0.39	0.87	
3	1606	0.79	3	2218	-0.35	0.24	1.14	18	1530	0.88	18	2118	-0.04	0.38	0.91	
4	0418	0.82	4	1018	-0.41	0.22	1.23	19	1406	0.71	19	0924	-0.16	0.31	0.87	
4	1624	0.83	4	2306	-0.44	0.21	1.27	19	1548	0.94	19	2148	-0.04	0.45	0.98	
5	0524	0.86	5	1130	-0.43	0.23	1.29	20	0448	0.90	20	1000	0.02	0.48	0.88	
5	1742	0.96	6	0012	-0.48	0.26	1.44	20	1618	1.03	20	2236	-0.06	0.46	1.10	
6	0624	0.89	6	1206	-0.54	0.19	1.43	21	0454	0.80	21	1100	-0.17	0.33	0.98	
6	1842	0.93	7	0136	-0.58	0.17	1.51	21	1624	0.94	21	2306	-0.18	0.39	1.12	
7	0654	0.82	7	1318	-0.57	0.13	1.39	22	0506	0.88	22	1048	-0.14	0.38	1.02	
7	1912	0.96	8	0136	-0.56	0.22	1.52	22	1730	1.00	23	0000	-0.20	0.42	1.20	
8	0724	0.87	8	1348	-0.47	0.21	1.34	23	1630	1.14	23	1148	-0.02	0.51	1.16	
8	1930	0.96	9	0242	-0.63	0.18	1.59	23	1830	1.40	24	0048	0.19	0.78	1.21	
9	0906	0.81	9	1442	-0.34	0.22	1.15	24	0654	1.14	24	1248	0.08	0.61	1.06	
9	2112	1.16	10	0330	-0.30	0.39	1.46	24	1854	1.19	25	0106	-0.12	0.50	1.31	
10	0918	0.77	10	1524	-0.38	0.20	1.15	25	0654	0.83	25	1312	-0.18	0.32	1.01	
10	2130	0.90	11	0400	-0.48	0.20	1.39	25	1930	1.00	26	0206	-0.28	0.34	1.28	
11	1006	0.53	11	1554	-0.50	0.01	1.02	26	0818	0.68	26	1400	-0.29	0.18	0.96	
11	2218	0.68	12	0500	-0.42	0.13	1.10	26	2000	0.82	27	0236	-0.35	0.24	1.17	
12	1048	0.48	12	1706	-0.31	0.07	0.79	27	0848	0.59	27	1442	-0.28	0.17	0.87	
12	2312	0.68	13	0518	-0.28	0.19	0.96	27	2124	0.82	28	0400	-0.36	0.25	1.19	
13	1130	0.59	13	1854	-0.17	0.20	0.76	28	0930	0.63	28	1518	-0.28	0.20	0.91	
13	2324	0.72	14	0706	-0.10	0.30	0.82	28	2224	0.93	29	0348	-0.10	0.41	1.03	
14	1242	0.54	14	1930	-0.24	0.16	0.78	29	1100	0.78	29	1618	-0.18	0.27	0.96	
15	0112	0.47	15	0706	-0.30	0.10	0.77	29	2242	0.77	30	0536	-0.35	0.22	1.12	
15	1224	0.42	15	1842	-0.20	0.13	0.62	30	1136	0.60	30	1748	-0.30	0.15	0.91	

# Bathymetry

## 7

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in March and the survey(s) in April on profile line 188, located 517 m south of the pier.

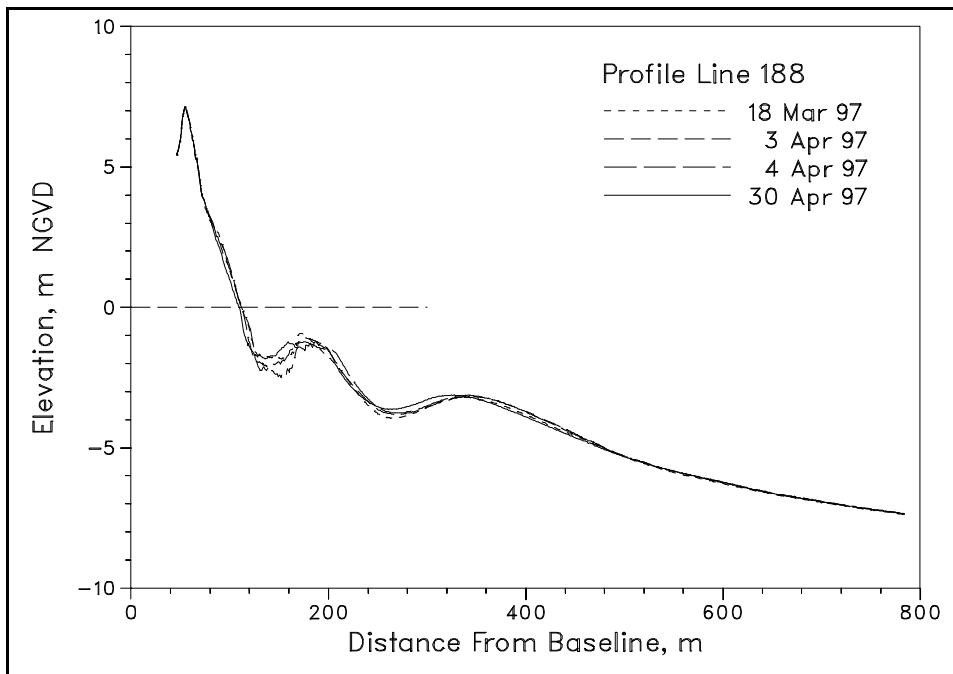


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1997. Cross-hatched areas indicate changes to the annual envelope which occurred in April.

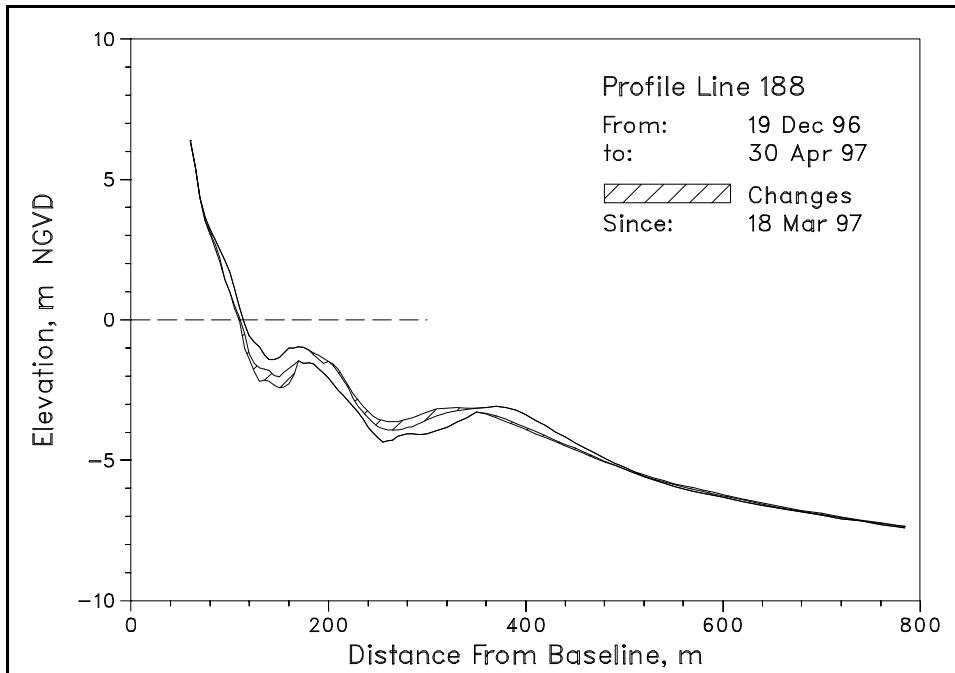
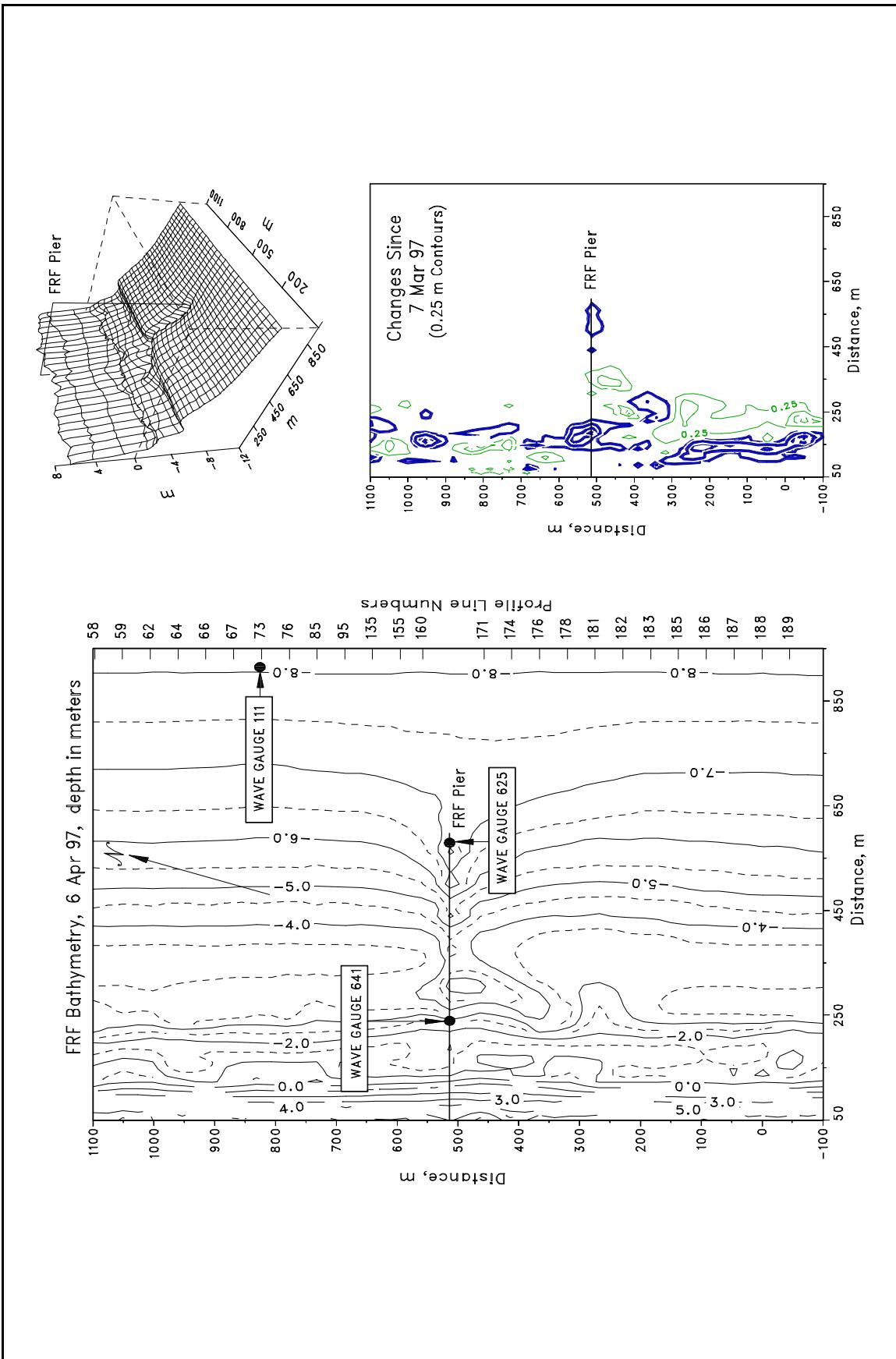


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 6 April. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



# Special Events

## 8

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A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

	<u>Start</u>	<u>End</u>
	1 Apr (0734)	2 Apr (1108)
	23 Apr (1816)	24 Apr (1000)

B. Storm Synopsis.

1-2 Apr Northeasterly winds were funneled between a high pressure system over Michigan and a low pressure system offshore of Delaware. Maximum winds reached 18 m/s at 1516 EST on 1 April. The minimum atmospheric pressure was 1005 mb. The maximum  $H_{mo}$ , at gauge 625, reached 2.6 m ( $T_p=12.8$  s) at 1516 EST on 1 April. There was no precipitation.

23-24 Apr Winds associated with a low pressure system over Cape Hatteras, reached a maximum of 11 m/s at 2042 EST on 23 April. The minimum atmospheric pressure was 994 mb. The maximum  $H_{mo}$ , at gauge 630, reached 2.3 m ( $T_p=7.8$  s) at 1900 EST on 23 April. There was 43 mm of precipitation.